Volume 2 DECEMBER 13, 1927 Number 6

BULLETIN

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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

OF THE

ANNUAL MEETING, NASHVILLE

DECEMBER 28-30, 1927

IN AFFILIATION WITH SECTION B—PHYSICS—OF
THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT
OF SCIENCE

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

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BULLETIN

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AMERICAN PHYSICAL SOCIETY

Published six times per year

Subscription price: $1.00 per year

The Bulletin of the American Physical Society is published six times a year during the months of February (2 issues), April, June, November, and December at 450 Ahnaip Street, Menasha, Wisconsin.

Address correspondence to Secretary H. W. Webb, Columbia University, New York, N. Y.

Entered at the post office at Menasha, Wisconsin, as second class matter.

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ANNUAL MEETING, NASHVILLE, DEC, 28, 29 and 30, 1927

In Affiliation With

SECTION B—PHYSICS—OF

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The Twenty-ninth Annual Meeting (the 148th regular meeting) of the American Physical Society will be held in Nashville at the Ward-Belmont School on Wednesday, Thursday and Friday, December 28, 29, and 30, 1927, in affiliation with Section B—Physics—of the American Association for the Advancement of Science. All regular sessions of the Physical Society and the joint session with Section B will be held in the Chapel of the Ward-Belmont School.

Opening Session of the A. A. A. S. The opening session of the A. A. A. S. will be held on Monday evening. For further details of the A. A. A. S. program see *Science* for December 2nd.

Joint Session with Section B—Physics—A. A. A. S. On Wednesday afternoon, December 28, there will be a joint session with Section B. The program will open with the address of the Retiring Chairman of Section B, PROFESSOR WILLIAM DUANE of Harvard University on "*The General Radiation.*" This will be followed by an address by DR. C. J. DAVISSON of the Bell Telephone Laboratories, Inc., who will speak on "*Diffraction of Electrons by a Crystal of Nickel.*"

Josiah Willard Gibbs Lecture. On Wednesday afternoon at 4:30 o'clock DR. E. W. BROWN of Yale University will deliver the Josiah Willard Gibbs Lecture on "*Resonance in the Solar System,*" in the Chapel of the Ward-Belmont School.

Presidential Address. On Thursday afternoon, December 29th, PROFESSOR KARL T. COMPTON will deliver his presidential address on "*Recent Studies of the Electrical Discharges in Gases.*"

Dinner. On Thursday evening at 6:30 o'clock there will be a dinner for the members of the Society and of Section B and their friends at the Ward-Belmont School. *Members must secure tickets before noon on Wednesday.* The cost of the dinner will be $2. per person.

General Business Session. The general business session of the American Physical Society will be held at eleven o'clock on Friday morning.

CALENDAR

All sessions of the Physical Society and Section B will be held in the Chapel of the Ward-Belmont School.

Monday evening		Opening session of the A.A.A.S.
Wednesday morning	10 o'clock	Papers 1–11.
Wednesday afternoon	2 o'clock	Joint session with Section B. Vice-Presidential Address by PROFESSOR WILLIAM DUANE; address by DR. C. J. DAVISSON.
	4:30 o'clock	Willard Gibbs Lecture by PROFESSOR E. W. BROWN.
Thursday morning	10 o'clock	Papers 12–22
Thursday afternoon	2 o'clock	Presidential Address by PROFESSOR KARL T. COMPTON. Papers 23–28.
Thursday evening	6:30 o'clock	Dinner at the Ward-Belmont School.
Friday morning	10 o'clock	Papers 29–37
	11 o'clock	Annual Business Session
Friday afternoon	2 o'clock	Papers 38–48

The supplementary papers Nos. 49–53 may be called for at the end of any regular session.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at 1500 University Avenue, S. E., Minneapolis, Minnesota.

GENERAL INFORMATION

For further information in regard to sessions, meetings, receptions, exhibitions, excursions, etc., see the General Program, of the A. A. A. S., which will be available at the registration offices in the Andrew Jackson Hotel at Nashville. See also the Preliminary Announcement of the A.A.A.S., printed in *Science* for December 2nd.

Headquarters for Physicists. Accommodations for members of the Physical Society and of Section B have been reserved in the Ward-Belmont School Dormitories. Applications for reservations should be sent to *Professor C. R. Fountain, care of Ward-Belmont School, Nashville, Tennessee,* and should be mailed not later than December 15th. State *Physics* on your application. The number of single rooms being very limited a member applying late will be assigned with some other member of the Society to a double room with twin beds. If members request any special groupings, these will be arranged for if possible.

Payment for rooms and meals will be made in advance at the time of registration in the Post Office Lobby of the School.

Price Schedule: Room, $2 per day per person; breakfast, $0.40; lunch $0.70; dinner, $0.90.

Address your mail in care of Ward-Belmont School.

Further information as to hotels will be found in recent numbers of *Science.*

Railroad Rates. Any person attending the meetings of the A.A.A.S., or its Affiliated Societies, may take advantage of the reduced railroad rates, on the usual certificate plan. The traveler should purchase a one-way, full-fare, through ticket to Nashville and secure at the same time a *Standard Certificate Form.* This certificate must be validated at the registration rooms of the A.A.A.S., at the time of the meeting; it will then entitle the owner to a return ticket by the same route at half the full fare, within the usual time limits.

Registration. Members should register immediately upon arrival at the registration offices of the A.A.A.S. in the Andrew Jackson Hotel.

A.A.A.S. Registration Fee. The A.A.A.S. registration fee is to be one dollar, payable on arrival, at the registration offices in the Andrew Jackson Hotel in Nashville. This fee will be remitted to life members of the Association, to annual Association members who have paid their annual dues for the current year, and to associates for the meeting. If dues have not previously been paid they may be paid at the registration offices. The dues of new members will also be received there. New members pay the regular five dollar entrance fee and the first annual dues (five dollars) and their membership subscription to the journal (Science or the Scientific Monthy) begins January 1. The entrance fee is remitted in the case of members of the Physical Society. Associates for an annual meeting pay the associate fee of five dollars and do not receive the journal. Registration entitles the person registering to a copy of the General Program and its supplements, to the official badge, to all the general privileges of the meeting and to the validation of *one* railway certificate.

Other meetings for the current season are as follows:

149. February 25, 1928. New York.
150. Pacific Coast Section—Place not yet determined.
151. April 20–21, 1928. Washington.
152. June 12–16, 1928. Pomona College.

HAROLD W. WEBB, *Secretary,*
December 13, 1927. Columbia University, New York City

PROGRAM

WEDNESDAY MORNING AT 10 O'CLOCK

1. A simple color analyzer. T. D. PHILLIPS, Marietta College.—Using a differential color mixer and a set of filters a rapid method of color analysis of pigments has been devised. The results closely approximate those obtained by more elaborate means.

2. The use of the grid-glow tube as an electrostatic voltmeter. T. R. WILKINS and F. B. FRIEND, University of Rochester.—The neon grid-glow tube has been used for the measurement of potentials applied between the grid and anode: the anode and cathode being shunted by a variable capacity. The period of discharge can be varied through wide limits by altering the plate potential, grid resistance (of order of 10 megohms) and shunt capacity. By suitable adjustment, great sensitiveness in the range 0-1 volt grid potential can be secured making the tube a valuable instrument for the measurement of small potentials where the quantity is very small. Under certain conditions, the period of discharge is directly proportional to the capacity shunted between the anode and cathode. A method is thus given for the comparison of capacities.

3. An electrical method of harmonic analysis. S. LEROY BROWN, University of Texas.—The plan of this method of harmonic analysis of a periodic electromotive force is to exaggerate the measured effect of each higher frequency component approximately proportional to the cube of the order of the harmonic. The electromotive force to be analyzed furnishes current into an input circuit, consisting of a fixed, known capacity and a fixed, known inductance in series, when the values of the capacity and inductance have been so chosen that the input circuit tunes to a frequency higher than the frequency of the highest order harmonic that is being measured. Another inductance is loosely coupled with the inductance of the input circuit and a variable condenser across this second inductance permits the second circuit to be tuned to the fundamental or to one of the several harmonics of the current that is flowing in the input circuit. A vacuum tube voltmeter is connected across the tuning condenser and the relative amplitude of harmonic to fundamental is calculated from the peak values of voltmeter readings, calculated values of the input impedance, measured values of the resistance of the tuned circuit at the respective frequencies and the order of the harmonic.

4. Some experiments concerning the nature of the sensitive point in the Geiger counter. L. F. CURTISS, Bureau of Standards.—A study has been made of a number of different treatments for the points used in the Geiger electrical counter. Following the suggestion put forward by Geiger (Zeits. f. Phys. **27,** 7, (1924)) that the action of the counter might be readily understood if the point in its sensitive condition is coated with a film of high electrical resistance, points have been prepared by coating them with materials which might be expected to give such a film. Although in most cases some beneficial effect was noted, few were very satisfactory as regards permanence. On treating steel points with phosphoric acid, and some similar substances, it has been found possible to produce points which are very sensitive and reliable. The method has also been found to work repeatedly without failing, a great advantage over the flame treatment. Geiger's view of the nature of the action of the counter is more nearly in accord with the results of these experiments than the view expressed by Kutzner (Zeits. f. Phys. **23,** 117, (1924)).

5. Completion of 75 cm reflecting telescope and photoelectric photometer. ROBERT H. BAKER, University of Illinois.—The new apparatus will be used for studies of minute variations in the quantity and quality of starlight. Disks of borosilicate crown glass for the telescope mirrors were made by the Spencer Lens Company and figured by John E. Mellish. All mechanical and electrical work was done by the J. B. Hayes Machine Company. The ratio of the 75 cm primary mirror, aperture to focal length, has the unusual value 1 to $2\frac{1}{2}$. The effective ratio at the Cassegrainian focus is 1 to 12. A quartz reflecting prism in the cell box may be rotated so as to divert the beam of starlight upon either of two photo-electric cells. The rates of increase of positive potential of the cells are measured by two string electrometers which hang in gimbals from the cell box. Sliding electrical contacts are avoided in this arrangement. Kunz cells are used, one caesium, the other sodium or potassium. Preliminary observations suggest that the apparatus will serve the purpose for which it was designed.

6. A triode amplifier for small direct currents. ALEXANDER MARCUS, The College of the City of New York.—Most of the methods of using thermionic vacuum tubes for the purpose of amplifying small direct currents relay either on the Wheatstone network or on the potentiometer principle in separating the normal value of anode current from the small change superimposed upon this value by the much smaller grid circuit which is being amplified. These balance methods are found to be highly unstable owing to the large disturbances produced by slight changes in the various battery voltages. It is found that the simplest method of maintaining stable working conditions whenever the current amplification does not exceed several hundred is to employ only an "A" battery with the triode, the filament voltage being adjusted just enough below normal to reduce the anode current to zero. Lowering of the filament voltage has the effect of minimizing deterioration of the filament while the current amplification is not seriously reduced thereby. The life of the tube is also prolonged indefinitely and the calibration of the tube-galvanometer combination remains permanent. This type of "thermionic galvanometer" is being employed to measure ionization currents, photo-electric currents, and piezo-electric currents of magnitudes considerably below the range of the galvanometer when used without the triode.

7. The use of the cathode-ray oscillograph in the study of resonance phenomena in piezo-electric crystals. K. S. VAN DYKE, Wesleyan University.—The piezo-electric resonator in series with a known large resistance (A) forms one side of a bridge; the other side consists of a known impedance in series with a second known large resistance (B). The deflecting systems of the cathode-ray oscillograph are connected so that one indicates the potential across A and the other that across B. When a source of alternating potential whose frequency is independent of any reaction from the resonator is applied to the bridge, the oscillograph indicates by a Lissajous figure the relative magnitudes and phases of the currents in the two arms. The impedance of the resonator at frequencies near resonance may be computed from measurements on the figure for those frequencies, and the constants of the electric network equivalent of the resonator (Phys. Rev. **25,** 895, (1925)) obtained therefrom. The figure also readily indicates whether the resonator is responding to the fundamental or to some harmonic in the source. The work of determining the natural vibration frequencies of quartz resonators and their equivalent networks is in progress.

8. An improved form of cathode ray oscillograph. R. H. GEORGE, Purdue University.—This oscillograph was designed for maximum flexibility, in order to be readily adaptable to a wide variety of work. It is constructed almost entirely of metal, and arranged for inserting photographic plates and films in the vacuum to obtain permanent records of transient phenomena. By employing interchangeable cathode parts the accelerating potential of the beam can be varied from less than 100 volts to thousands of volts, depending on the deflectional and photographic sensitivities required. The deflecting plates are adjustable, and as many as three pairs can be used at one time, making possible three simultaneous deflections by electrostatic fields. Magnetic deflecting coils may also be employed when desirable. Methods are described for making leak proof joints, for interchangeable parts, lead-in connections and for driving a film drum from outside the vacuum. Requirements for emulsions sensitive to electron bombardment are discussed, and methods described for making sensitive emulsions, and for sensitizing the ordinary photographic plates.

9. Electrical resistance and magnetic permeability of iron wire at radio frequencies. G. R. WAIT, Carnegie Institution, F. G. BRICKWEDDE and E. L. HALL, Bureau of Standards.—Mitiaev observed (Zeits. f. Phys. 1926) that the high frequency resistance of iron wire underwent a critical change at about 100 meters wave-length. This he considered a confirmation of the results of Wwedensky and Theodortschik on the critical change in permeability of iron. In view of contrary results on permeability by Wait (Phys. Rev. **29,** 566 (1927)) it was decided to investigate the high frequency resistance. The resistances of wires intermediate in size between those used by Mitiaev were measured by the resistance-variation method as described in Bureau of Standards Circular 74. The investigation was carried out between 79 to 120 meters. No critical change within the observable accuracy was detected. The difference in results between those of Wwedensky and Theodortschik and those of Wait, on the permeability of iron in alternating fields might be due to a difference in the kind of iron. The variation in permeability of a sample in which the phenomena had been observed by Wwedensky and

Theodortschik was determined with the same apparatus and under the same conditions as by Wait. Smaller fields and various methods of binding the sample were also tried. In no case was a critical variation observed.

10. The overshooting of the temperature of a tungsten filament. LESTER I. BOCKSTAHLER, Northwestern University.—Using a double strip oscillograph, simultaneous photographic records were made of the heating current in a straight filament tungsten lamp and the thermionic current emitted by the central portion of the filament. The records showed that, upon closing the circuit, the expected momentary overshooting of the heating current was followed by a marked overshooting of the thermionic current. Since the thermionic current indicated the temperature of the filament, there was an overshooting of the power consumption when the current was turned on the cold filament. As a check, one strip of the oscillograph was connected to record the heating current and the other to record the potential drop across the central portion of the filament. The product of the corresponding ordinates of these records and an appropriate constant, obtained from voltmeter and ammeter readings, also showed an initial overshooting of power. The magnitude and duration of this initial surge depended on the final temperature and the size of the filament. The "end effects" of the filament were eliminated by the use of "potential leads" and guard rings. To minimize the inductance and the potential drop in the line, a large capacity storage battery, joined to the lamp with short heavy copper leads, served as a source of current.

11. Specific resistance and purity of sodium electrolyzed through soda-glass. J. RUD NIELSEN, University of Oklahoma.—(1) The specific resistance was measured by observing the resistance of a U-shaped capillary tube filled first with mercury and afterwards with sodium. Taking the specific resistance of mercury to be $94073\times10^{-9}\times(1+0.0008892t+0.000000994t^2)$ the following results were obtained. For solid sodium between 30° and 90°C.

$$4661\times10^{-9}\times(1+0.00484t);\text{ for liquid sodium below 160°C.}$$
$$9828\times10^{-9}\times(1+0.00354(t-100)+0.00000039(t-100)^2).$$

(2) The sodium was obtained as described by Burt (J.O.S.A. & R.S.I. **2**, 87 (1925)). A spectroscopic analysis, by a method which is a modification of that developed by Gooch and Hart (Am. J. Sci. **42**, 448, (1891)), showed that the sodium contained 0.08 percent potassium. No other impurities were detected.

WEDNESDAY AFTERNOON AT 2 O'CLOCK

Joint Session of the American Physical Society with Section B of the A.A.A.S.

The session on Wednesday afternoon, December 28, at two o'clock, will be in charge of the officers of Section B—A.A.A.S. PROFESSOR WILLIAM DUANE, the retiring Vice-President and Chairman of Section B, will deliver an address entitled "*The General Radiation.*"

This will be followed by an address by DR. C. J. DAVISSON entitled "*Diffraction of Electrons by a Crystal of Nickel.*"

After this address there will be discussions of this subject.

At 4:30 o'clock in the same room, PROFESSOR E. W. BROWN, of Yale University will deliver the Josiah Willard Gibbs Lecture on the subject "*Resonance in the Solar System.*"

12. The resolving power of an octahedral crystal for x-rays. CARLETON C. MURDOCK, Cornell University.—An investigation of the relation between the size of octahedral crystals of the cubic system and the width of the lines of their x-ray power spectrogram shows that the half intensity width B of a line is given by an equation of the same form as that developed by Scherrer for the case of cubic crystals; $B = K\lambda/D \cos(\theta/2)$, where λ is the wave-length of the x-rays used, θ the angle of diffraction and D the length of the crystal measured between opposite corners. K is a numerical coefficient approximately equal to 1.6. Its value is a function of the indices of the spectral line. Several experimenters have used Scherrer's equation to compute the size of colloidal particles of materials such as gold and platinum, which ordinarily crystalize in the octahedral form. If we compute the particle volume from their data considering the crystals as octahedral the result is about twenty percent less than that obtained by assuming the crystals to be cubes.

13. The molecular and crystal structure of ethane. JARED KIRTLAND MORSE, University of Chicago.—The results of this investigation indicates that while the bond in the ethane molecule between the carbon atoms is the generally accepted two-electron bond that between the hydrogen nuclei and their respective carbon atoms consists of a single electron. The following interatomic distances are found C–C 1,26A and C–H 1.54A. The carbon atoms appear to be cubical with a radius R of 0.77A as observed in the diamond lattice. In the crystal structure of ethane these molecules are arranged in a close-packed hexagonal array. The lattice constants of this structure referred to orthorhombic axes are found to be geometrically related to the radius R of the carbon atom. $a_0 = 4R(6)^{1/2} = 7.54$A. $b_0 = 4R(2)^{1/2} = 4.36$A and $c_0 = 32R/3 = 8.21$A. The carbon nuclei are found to have the positions 0 0 0, 1/12 7/12 5/8, 1/6 1/2 1/2, 5/12 7/12 1/8, 1/2 1/2 0, 7/12 1/12 5/8, 2/3 0 1/2, 11/12 1/12 1/8, and the hydrogen nuclei the positions 0 1/3 15/16, 1/12 1/4 3/16, 1/6 5/6 15/16, 1/4 3/4 3/16, 1/3 1/3 5/16, 5/12 1/4 3/16, 1/2 5/6 15/16, 7/12 3/4 3/16, 2/3 1/3 15/16, 3/4 1/4 3/16, 5/6 1/6 15/16, 11/12 3/4 3/16, 0 1/3 7/16, 1/12 1/4 11/16, 1/6 5/6 7/16, 1/4 3/4 11/16, 1/3 1/3 7/16, 5/12 1/4 11/16, 1/2 5/6 7/16, 7/12 3/4 11/16, 3/3 1/3 7/16, 3/4 1/4 11/16, 5/6 1/6 7/16, 11/12 3/4 11/16. The diffraction effects computed from the above structure agree within the limits of experimental error with the measurements of Mark and Pohland (Z. Krist. **62,** 103–109 (1925)). The 004 plane gives an abnormal reflection. It should be absent when the diffracting centers are considered to be concentrated at the centers of the carbon atoms but it is present as observed when the structure factor is computed from the electronic positions.

14. The lattice constants and the space groups of $BaCO_3$ and $SrCO_3$. THOMAS A. WILSON, General Electric Co.—Precision x-ray photographs were taken of Merck's $BaCO_3$ and $SrCO_3$ by the powder method with Mo K radiation using NaCl as a calibrating substance. In both substances the fundamental lattice is the simple orthorhombric Γ_0, and the unit cell contains 4 chemical molecules. The unit cell of $BaCO_3$ has the dimensions: $a_0 = 5.252 \pm .001$A, $b_0 = 8.828 \pm .002$A, $c_0 = 6.544 \pm .001$A. The calculated density is $4.291 \pm .004$. The axial ratios (0.5949:1:0.7413) and the density (4.28 – 4.37) given by Groth are in agreement with the data. The unit cell of $SrCO_3$ has the dimensions: $a_0 = 5.118 \pm .003$A, $b_0 = 8.404 \pm .005$A, $c_0 = 6.082 \pm .004$A, and the calculated density is $3.722 \pm .006$. The dimensions agree with the axial ratios (0.6090:1:0.7237) given by Groth, but the density (3.680 – 3.716) of Groth is somewhat lower than that given by the x-ray. The space group of $BaCO_3$ is $2Di - 16(X = a)$ agreeing with that found by Wyckoff (Am. Jour. of Sci. **9,** 145, (1925)) for aragonite. That of $SrCO_3$ is probably $2Di - 16$ $(X = a)$ but because of the fogging of the films it was impossible to establish this with the same certainty as that of $BaCO_3$.

15. On the x-ray analysis of chromium-nickel alloys. F. C. BLAKE, JAMES O. LORD, W. C. PHEBUS and A. E. FOCKE, Ohio State University.—It has previously been reported that chromium distorts the nickel lattice up to 64 percent chromium but it was not possible until now to determine the correct status of the alloy for higher percents of chromium, although it was reported that a body-centered chromium nickel lattice separated out for alloys rich in chromium. By Proper etching and x-ray analysis of the undissolved material it is shown that a third phase which is rhombohedral, with many lines, is present. It is this rhombohedral lattice together with the body-centered lattice that is present for alloys containing from 65

to 85 percent chromium. Microphotographs taken of the samples confirm the presence of three phases.

16. Indices of refraction of platinum for x-rays of long wave-length. ELMER DERSHEM, University of California.—Using a total reflection method with apparatus placed in a vacuum spectrograph the indices of refraction of platinum have been measured over the wave-length range 1.279 to 7.01 Angstrom units, yielding values of $1-\mu$ of 27.3×10^{-6} to 663×10^{-6}. This region extends to lower frequencies than those of the absorption limits of the K, L, and M series. The results show that the simplified form (neglecting absorption) of the Drude-Lorentz dispersion formula can not be used although in the parts of the region farthest removed from an absorption limit it leads to results of the same order of magnitude as those found experimentally.

17. X-ray diffraction in liquid normal paraffins. G. W. STEWART, University of Iowa.—X-ray diffraction was studied in liquid pentane, hexane, octane, nonane, decane, dodecane, tetradecane and pentadecane. There was one diffraction peak only, instead of two as found by Stewart, Morrow and Skinner with the primary alcohols and certain isomers and with normal fatty acids. This peak was located at the same angle as with the other liquids referred to and possessing normal carbon chains. This angle, interpreted by Bragg's law, indicates a lateral separation of 4.6A. The absence of the second peak, indicating a longitudinal arrangement is accounted for by a consideration of the molecular structure and the longitudinal forces. It is significant that in six of the nine paraffins, the diffraction intensity does not decrease as the diffraction angle approaches zero. Assuming that the carbon atom occupies a length in the chain of 1.3A, the hydrogen atom, 1A, and that the volume of the molecule is the square of the lateral spacing by the length, the computed values of densities of the seven normal paraffins are correct to within less than 4 percent, or a mean of 2 percent. The other two paraffins are evidently isomers instead of normal and are not included. Two additional faint peaks are found with pentadecane and tetradecane. The corresponding spacings are 2.1A and 1.23A. The nearness of these to the repetitive values of 2.0A and 1.26A which are found in the diamond is suggestive.

18. Fine structure in the K series of molybdenum. BERGEN DAVIS and HARRIS PURKS, Columbia University.—We have already shown that by proper arrangement of crystals the resolving power of the double x-ray spectrometer may be much increased. (Proc. Nat. Acad. Sci. **13**, June, 1927.) With both crystals at first order reflection the Kβ doublet was completely resolved. It has since been found that by placing crystals for higher orders of reflection, the resolving power is increased. If $d\lambda$ is the wave length interval to be observed $2nd\lambda = 2d \cos \theta_n d\theta_n$. The angular separation $d\theta_n$ increases with order. In addition the resolving power is further increased by the fact that the rocking curves become narrower at higher order. Measurements here given were made at second order on both crystals. Fine structures were observed as follows all on long wave-length side of parent line: β_1' at .17 X-U from β_1; α_1' at .085 X-U from α_1 and α_2' at .096 X-U from α_2. The α_2' line was diffuse indicating that it might be further resolved into components. Measurement attempted at third order on α_1, gave same $d\lambda$ as at second order.

19. The K x-ray absorption edge of iron. H. R. VOORHEES and GEO. A. LINDSAY, University of Michigan.—The K x-ray absorption edge of iron was photographed, using as reflecting crystals several different iron compounds—pyrite, hematite, arsenopyrite, epidote, and lepidomelane. The iron in these crystals gave the characteristic K absorption edge without the use of any other absorbing screen. The absorption was also obtained by screens of iron compounds, and by a thin screen of electrolytic iron. When screens were employed, a sylvin crystal was the reflector. A complicated fine structure of the edge was observed, extending over a range of more than 200 volts. The spectral range of fine structure due to the stopping of the ejected electron in different virtual orbits would be much smaller than that obtained here, and such an hypothesis is quite inadequate to explain the present observations, especially in the case of the uncombined element. It is, therefore, supposed that at least part of the fine structure is due to the simultaneous ejection of two or more electrons from the atom.

20. A diagram of the properties of crystals. JAKOB KUNZ, University of Illinois.—In his lectures on problems of atomic dynamics, delivered at the Massachusetts Institute of Technol-

ogy, M. Born has given a diagram (due to Heckmann) of the crystalline properties omitting however, the magnetic properties. A new diagram has been made which includes the magnetic properties as well as their relations to temperature and to mechanical and electrical forces.

21. Thermoluminescence excited by x-rays. Further experiments upon synthetically prepared materials. FRANCES G. WICK and MABEL K. SLATTERY, Vassar College.—Many materials originally inactive are made thermoluminescent by exposure to x-rays. $CaSO_4$ containing a small amount of manganese in solid solution shows this effect strongly and has been previously studied by the authors. The present report gives a continuation of this work upon sulphates of cadmium, calcium, sodium and zinc containing a small amount of manganese. Exposure to x-rays produces two kinds of change in the material. One of these results in a thermoluminescence which comes up quickly upon heating and lasts for a very short time while the other is shown by a luminescence which comes up more slowly and lasts longer. If the material is allowed to stand at room temperature after exposure the first effect disappears in a few hours while the second may last for months. Both of the effects may be preserved indefinitely by keeping the specimen in liquid air after exposure. The decay of thermoluminescence was studied using different temperatures of observation, different temperatures of exposure and different voltages on the x-ray tube. Exposure to ultra-violet light of a definite frequency was found to kill the effect produced by exposure to x-rays. The results obtained are compared with effects of exposure to cathode rays as described by Wiedemann and Schmidt.

22. Further studies in the effect of x-rays upon certain optical properties of liquids and glass. FRED ALLISON, Alabama Polytechnic Institute.—Magnetic and optical rotations induced in several liquids when exposed to x-rays have been observed by the author (Chicago Meeting, 1927). In these liquids the induced optical rotation is left-handed, while the induced magnetic rotation is in the same direction as, and increases with the Faraday rotation. By varying the field strength the induced magnetic and optical rotations may be made to compensate, the former predominating in stronger and the latter in weaker fields. In sugar and tartaric acid solutions x-rays increase the right-handed rotation roughly in proportion to the concentration. Since distilled water traversed by x-rays shows a slight left-handed rotation, it is possible to find a concentration of the sugar or acid solution in which the rays induce no rotation. A left-handed rotation appears as the solution is further diluted and a right-handed one as its concentration is increased. X-rays are found to induce in glass in a magnetic field a rotation in opposition to the Faraday rotation. The above induced rotations as observed are all small, being of the order of a few minutes. They increase with the potential across the x-ray tube.

THURSDAY AFTERNOON AT 2 O'CLOCK

Presidential Address

The afternoon session will open with the Presidential Address by PROFESSOR KARL T. COMPTON on "*Recent Studies of the Electrical Discharges in Gases.*"

After the address the regular session for the reading of papers will be resumed.

23. Positive ions reflected from a metallic surface. R. W. GURNEY, Princeton University. (Introduced by H. D. Smyth, Princeton University.)—The velocities and intensities of potassium ions scattered from a platinum surface have been measured by allowing the scattered ions to pass through the slits into the electric and magnetic fields of a positive ray box. The source was a Kunsman filament mounted on a ground glass joint so that the target could be bombarded from any angle. On varying the field in the positive ray box, and plotting intensities against the field-strength, a peak is obtained in the usual way, and from the position of this peak the velocity of the reflected particles is known. It was found that when the target was cold the position of the peak was almost independent of the velocity of the primary beam, the scattered ions never having more than a few volts energy when that of the incident beam was raised from 8 volts to 80 volts. But when the target was glowing (by means of a heating current) the scattered particles retained from 10% to 60% of their initial energy, their energy

varying continuously with the angle of incidence and being greater for smaller glancing angles. On allowing the target to cool, the peak rapidly returned to its former position at a few volts, presumably due to a contamination of the surface by grease vapor from the ground glass joint.

24. Diffraction of electrons by a single layer of gas atoms adsorbed upon a nickel crystal. C. DAVISSON AND L. H. GERMER, Bell Telephone Laboratories, Inc.—The first gas atoms to adhere to a clean $\{111\}$ surface of a nickel crystal give rise, under electron bombardment, to plane grating electron diffraction beams, which show that these first atoms arrange themselves in a structure similar to a $\{111\}$ layer of nickel atoms, but with twice the scale factor of the latter. These plane grating beams pass through broad maxima due to constructive interference with differential diffraction beams arising from two different classes of surface nickel atoms (Phys. Rev. **30**, 705 (1927)). There is some freedom in calculating from these data the separation of gas atoms from the plane of the surface nickel atoms; the gas atoms may lie above alternate second layer nickel atoms or above alternate third layer atoms, and for some of the maxima the order is uncertain. If the gas atoms are assumed to lie above alternate third layer nickel atoms and at about 3.A from the plane of the first layer atoms then the calculated occurrences of the diffraction maxima (6 in number) are in acceptable agreement with the six maxima which were observed (loc. cit.). This separation of 3.A is over twice the apparent separation of surface layers of nickel atoms (1.4A).

25. The relative activation of a nitrogen-hydrogen mixture by electrons and by K^+ ions in the formation of ammonia. C. H. KUNSMAN, Bureau of Chemistry and Soils, U. S. Department of Agriculture.—The activation chamber consisted of a pyrex bulb containing a tungsten filament as the electron source, an iron-potassium coated strip as the K^+ ion source, and a fine platinum gauze cylinder as the collector. The (N_2+3H_2) mixture at pressures of 1 mm and less was introduced in the bulb immersed in liquid air and the rate of decrease in pressure or formation of NH_3 was shown for various conditions of the hot surfaces. Results show that without an applied potential the iron-potassium catalyst surface is very much more active in the clean up than the tungsten, but that a large increase in the rate with tungsten takes place at electron speeds of 17 volts and over, while no appreciable increase is observed with K^+ ions from the catalyst surface up to 150 volts speed. These results are in agreement with other comparable properties of electrons and ions, such as ionization and secondary electron emission from surfaces.

26. On electrical fields near metallic surfaces. JOSEPH A. BECKER and DONALD W. MUELLER, Bell Telephone Laboratories, Inc.—If an electron must pass through surface fields in order to escape from the surface, a properly directed applied field, F, should partially neutralize the surface fields and hence increase the thermionic current i. A simple analysis shows that $d(\log_{10} i)/dF=(11600/2.3\ T)\times s$. T=surface temperature; s=distance from the surface at which the surface field equals F. For clean surfaces the observed current voltage relation can be accounted for if the only force acting on the escaping electron is due to its image field. For composite surfaces such as thorium on tungsten another field, due to the adsorbed ions, is superposed on the image field. Close to the surface this "adsorption field" is very intense and helps electrons escape thus decreasing the work function; farther from the surface this field reverses sign, grows to a maximum value and then steadily decreases. This reverse field has appreciable values at surprisingly large values of s. Hence the $\log i - F$ curve for composite surfaces is steeper than that for clean surfaces.

27. Secondary electron current as a function of crystal structure. H. E. FARNSWORTH, Brown University.—Several experimenters have attempted to correlate the breaks which appear in the secondary electron curve (secondary current as a function of primary energy) of a metal with soft x-ray and optical levels of the atoms composing the metal, but without much success. The results given here together with some previous ones show that the changes in slope of the secondary electron curve for copper in the region 0–40 volts are characteristic of the arrangement of the atoms at the metal surface, and not of the structure of the atoms themselves. The curve for a phosphor bronze target does not show the characteristics of the curve formerly obtained for copper. The curve for targets cut from a single crystal of copper is distinctly different from that previously obtained for a large number of targets taken from copper sheet.

28. A series of measurements of critical potentials of Hg vapor. J. C. MORRIS, JR., Princeton University.—A seven electrode tube was designed to determine the critical potentials of mercury by the various methods previously employed and to compare the efficiency of the different methods. By suitable connections the tube can be employed according to the Lenard method, inelastic impact method of Hertz and Franck, Franck and Einsporn method, Davis and Goucher method for distinguishing ionizing and radiating potentials, Hertz method for critical potentials by inelastic impacts, as well as the usual methods for determining ionizing potentials. The photo-electric methods have not yielded the resolution expected and several unexplained irregularities have developed. The radiating potentials have been resolved most successfully by the Hertz method. Using a molybdenum filament there was slight evidence of ionizing potentials above 10.4 volts but by employing a Wehnelt cathode burned at very low temperatures. These were resolved to check the values previously reported by Lawrence. Taking the lowest ionizing potential as 10.4, the values found were 10.4, 10.65, 11.34 and 11.8. From the curve the relative probabilities of the different types of ionization can be determined.

FRIDAY MORNING AT 10 O'CLOCK

Annual Business Session of the American Physical Society

This session will begin with the reading of the papers as given below. At 11 o'clock the reading of papers will be interrupted for the transactions of the business connected with the Annual Meeting of the American Physical Society. It is probable that the business session will require but a short time, after which the reading of papers will be resumed.

29. An analysis of the fine structure of the D_3-line of helium. H. R. WEI, University of Chicago.—The D_3-line of helium λ5875 has been found to be a triplet under conditions suitable for true spectroscopic resolution. A new type of discharge tube which is free from absorption and Stark effect and can be cooled with liquid air at reduced pressure was used. The D_3-line was photographed in the higher orders of a 30-ft Littrow with 8-inch and 10-inch gratings, and also with a 30-step echelon. Microphotometric traces of the photographs from both instruments show clearly the triplet structure of the D_3-line. An analysis of the traces gives the intensity ratio of 5:3:1 and the separation ratio of about 10.3:1 for the triplet. The results are in good agreement with the theoretical predictions of Heisenberg and the intensity measurements of Burger. A discharge tube similar to the one employed by Houston (Nat. Acad. Sci. Proc. **13,** pp. 91, (1927)) was examined. The appearance of the D_3-line with this tube was found to be chiefly due to self-reversal.

30. Self-reversed lines in the spectrum of mercury. L. H. DAWSON and W. H. CREW, Naval Research Laboratory.—Spectrograms in the region λ6000 to λ1860 were made of a mercury arc in quartz operating at atmospheric pressure and excited by a condensed discharge. Eleven arc lines and two spark lines were observed to be self-reversed. All of these arc lines, except λ2536, represent electron transitions originating on the 2^3P levels, which are the lowest energy levels of the excited Hg-atom. Furthermore, six of these lines start on the 2^3P_1 level, two on the 2^3P_0 level, and two on the 2^3P_2 level, indicating a predominent accumulation of electrons on the supposedly least stable orbit; the frequent collisions due to pressure possibly preventing the usual accumulation on the more stable orbits. By means of absorption, electrons appear to be raised to the 3^3D_1 level by two avenues of approach, to the 3^3D_2 level by one and to the 3^3D_3 level by none. Consistent with this is the observation that of three emission lines commencing on these levels, the most intense starts on the 3^3D_1 level, and the least intense on the 3^3D_3 level. The same holds for the 4^3D orbits. The arc when excited by 4000, 8000, and 16000 kilocycles at 5, 1, and 0.5 amperes respectively gave sharp atomic lines, and also molecular bands coincident with those usually observed in fluorescing mercury vapor.

31. Certain multiplets in the spectra of Cb III and Cb IV. H. E. WHITE and R. C. GIBBS, Cornell University.—Applying the irregular doublet law to the data already known for the

triad of multiplets $^3D_{1,2,3}-{}^3P_{0,1,2}$, $^3D_{1,2,3}-{}^3D_{1,2,3}'$ and $^3D_{1,2,3}-{}^3F_{2,3,4}$ $(ds-dp)$ in the two electron systems Sr I and Yt II, the corresponding multiplets for Zr III (Unpublished zirconium data obtained from C. C. Kiess) and Cb IV have been identified. Similarly the triad of multiplets $^4F_{2,3,4,5}'-{}^4D_{1,2,3,4}'$, $^4F_{2,3,4,5}'-{}^4F_{2,3,4,5}$ and $^4F_{2,3,4,5}'-{}^4G_{3,4,5,6}'$ (d^2s-d^2p) in the three electron systems of Yt I, Zr II has been extended to Cb III, and the stronger lines in the $^4F'G'$, multiplet of Mo IV have been identified. In passing successively from element to element in both of these iso-electronic systems the shift in the frequency of the radiated lines for each of these multiplets is approximately constant. Assuming that $(\nu/R)^{1/2}$ varies according to the Moseley Law, and that $\Delta(\nu/R)^{1/2}$ is independent of atomic number, in accordance with the irregular doublet law, and using the observed radiated frequencies of each element, and the known term values of Sr I, the term values of each level have been computed.

32. The regular displacement of certain multiplets for elements in the second long period. R. C. GIBBS AND H. E. WHITE, Cornell University.—The strongest lines and multiplets arising from the electron transition $4p$ to $4s$ in the presence of 0, 1, 2, $3 \cdot \cdot \cdot 10$, $3d$ electrons, for those elements in the first long period of the periodic table starting with K I, have been shown to follow a regular displacement on a frequency-atomic number diagram. A similar relation is also found to hold for the corresponding multiplets for elements in the second long period starting with Rb I. Here, however, the electron transition is from $5p$ to $5s$ in the presence of 0, 1, 2, $3 \cdot \cdot \cdot 10$, $4d$ electrons.

33. Characteristics of the neutral and of the singly and doubly ionized spectra of praseodymium, neodymium and samarium. ARTHUR S. KING, Mount Wilson Observatory.—A study of these spectra from λ2500 to λ7000 at various temperatures of the electric furnace and in the arc and spark has furnished material for a separation of the neutral and ionized spectra, the identification of a large number of neutral lines previously unrecognized, the temperature classification of the neutral spectrum, the selection of ionized lines of lower atomic level, and the identification of new lines, probably doubly-ionized, in the ultra-violet. As in the case of cerium, the neutral lines are brought out much stronger in the furnace than in the arc, and this development takes place within a limited temperature range, indicating in each spectrum a set of low, closely spaced energy levels. In the ultra-violet, the neutral spectrum fades rapidly, and the ionized more slowly, while a rich spectrum appears in the spark, which will probably prove to be that of double ionization. Of these lines, only a few in each spectrum had previously been measured. A notable complexity of line structure was observed in the singly ionized spectrum of praseodymium. Incomplete resolution indicates that with few exceptions each line consists of three to six components, the complexity being more general than in the case of the lanthanum spectrum.

34. Measurement of wave-length in the secondary spectrum of hydrogen between 3394A and 8902A. H. G. GALE, G. S. MONK, and K. O. LEE, University of Chicago.—The source was a specially constructed tube, operated by a 1 kw transformer, and cooled with running water. Using a Fabry-Perot interferometer and auxiliary concave grating spectrograph, wave-lengths of 95 strong lines in the secondary spectrum of hydrogen between 4171A and 6527A were measured. For 61 of these lines the probable error is 0.0012A or less; for none of them is it greater than 0.0033A. The spectrum between 3394A and 8902A was then photographed with a 21 ft focus concave grating in a Rowland mounting, with dispersion of 2.63A per mm and theoretical resolving power of 80,000 in the first order. Wave-lengths of 3064 lines were measured, using the 95 lines measured with the interferometer as standards. Where no such standards existed, the spectrum of iron was used. The mean error of most lines thus measured was less than 0.01A. Many uncertainties in previously published measurements are due to insufficient resolution of close groups of lines. It is believed that the present measures eliminate such uncertainties. Good agreement exists between these measures and those of Merton and Barratt, and Allibone. A systematic difference of 0.24A exists between these measures and those of A. H. Poettker in the extreme red, Poettker's measures being lower.

35. Structure of the OH bands. ROBERT S. MULLIKEN, New York University, Washington Square College.—(cf. Phys. Rev, **29**, 921; **30**, 387, 785). Each OH band comprises (*a*) six main branches (*b*) about six weak "satellite" series (*c*) another weak branch, extending toward high frequencies from each head (λ3064, Watson; λ 2811, Jack, Proc. Roy. Soc. 1927). The main branches (for which $\Delta j_k = \Delta j$) and four of the satellite series (for which $\Delta j_k \Delta) \neq j$ agree com-

pletely with the Hund's case *b* predicted structure for $^2S \rightarrow$(inverted) ^2P; except that these satellite series, although weak, are much stronger than predicted. Branch (*c*) is now identified as an *R* branch ($\Delta j = 1$,—but $\Delta j_k = 2$); a companion *P* branch, as yet unknown, may be expected. Occurrence of branch (*c*) and high intensity of satellite series show OH here as a transition case between CHλ3900 (good case *b*, six strong branches with $\Delta j = 0, \pm 1$ and $\Delta j_k = \Delta j$) and HgH (twelve strong branches governed by $\Delta j = 0, \pm 1$ without limitations on Δj_k, $-j_k$ not being quantized for the, here case *a*, ^2P state). The ZnH bands lie between OH and HgH in all these features.—Two satellite series (Dieke and Watson's σQ_1 and σQ_2) have $\Delta j_k = \Delta j$ like main branches, but differ by running counter to the usual "crossing-over" rules of σ-type doubling, constituting the first known exception to these rules.

36. Correlation of visible and near infrared absorption bands in colorless liquids. JOSEPH W. ELLIS, University of California.—Modifying an interpretation previously given (Phys. Rev. **27,** 298 (1926)), it is assumed that an anharmonic series of absorption frequencies originating in oscillations of the carbon-hydrogen bonded pair of atoms starts at $3.2-3.5\mu$. Data for such series have been compiled from observations with absorption cell thickness varying from 0.01 mm to 2.5m, the lowest wave-length members being found in Russell and Lapraik's (J. Chem. Soc. **39,** 168 (1881)) drawings of their visual observations in the visible spectrum. Wave-lengths for typical substances for which the data are most complete are given in microns for (a) benzene; (b) an alkyl derivative of benzene; (c) an amino derivative of benzene; and (d) a halogen derivative of a saturated hydrocarbon.

(a) Benzene. 3.27, 1.68, 1.15, 0.874, 0.713, 0.612, 0.535.
(b) Toluene: 3.38, 1.69, 1.15, 0.876, 0.72, 0.612.
1/74, 1.18, 0.91, 0.75, 0.637.
(c) Aniline: 3.22, 1.67, 1.14, 0.87, 0.72, 0.612.
(d) Chloroform: 3.32, 1.69, 1.15, 0.88, 0.715, 0.612.

Five of the bands of toluene have now been observed as double, revealing the separate effects of the C_6H_5 (phenyl) and the CH_3 (methyl) types of C-H bonds.

37. The absorption spectra of benzene and toluene in alcoholic solution. C. V. SHAPIRO AND R. C. GIBBS, Cornell University.—A study of the absorption spectra of benzene and toluene in alcoholic solution discloses the existence of several heretofore unreported absorption bands. In all 23 bands are found in benzene and 21 in toluene. Many of the new bands are narrow and in general appearance resemble somewhat the absorption bands of the vapors of these substances. Precautions were taken to prevent the presence of vapor between the light source and the slit of the spectrograph. Furthermore a study of the relative positions of the vapor and solution bands shows conclusively that none of the absorption bands found in solution can be ascribed to vapor. With the possible exception of one band belonging to the absorption spectrum of benzene, all of the bands for each substance can be arranged in a series, in accordance with a simple mathematical expression derived from the theory of band spectra. Evidence is also presented to show that the recent results reported by Smith, Boord, Adams and Pease, indicating a benzene-like structure for the absorption spectra of a number of organic compounds, were due entirely to the presence of benzene as an impurity.

FRIDAY AFTERNOON AT 2 O'CLOCK

38. On the mechanism of photo-electric emission. J. H. HSU, Cornell University.—On the assumption that when a quantum of radiation strikes an atom, its energy content is shared by the valence electron and the core of the atom, a simple theory is here described to explain the mechanism of photo-electric emission. According to this theory, the work function $h\nu_0$ should in general be equal to the lowest resonance potential of the substance under investigation. The curve showing the relation between the photo-electric emission and the incident wave-lengths should have humps at certain places. For weak illumination and long wave-length the relationship between photo-electric emission and intensity of incident light should not be linear. Experimental evidences and other phenomena of general interest are brought up and discussed in the light of this theory.

39. The effect of water vapor on the positive air ions. HENRY A. ERICKSON. University of Minnesota.—When initial positive air ions (mobility 1.87 cm/sec per volt/cm) and final positive air ions (motility 1.36 cm/sec per volt/cm) are passed into air containing water vapor

the number of 1.87 ions is at first increased and the number of final ions is diminished. The effect is as if the H_2O molecule gives up an electron to the final positive two-molecule air ion thus neutralizing it and forming in its stead a one-molecule H_2O positive ion. As a 1.87 ion is formed it has not been possible to determine if a similar exchange with the initial (1.87) air ion also takes place. No effect on the negative ion is observed.

40. The equation of state of a mixture determined from the equations of state of its constituents, and its application in determining the physical and chemical properties of a mixture in terms of those of the constituents. R. D. KLEEMAN, Schenectady, New York.—It is shown that the equation of state of a mixture (whose constituents may be partly or wholly combined into molecules) and the equations of state of the isolated constituents, have the functional forms

$$p=\psi((A_1M_a+B_1M_a+\cdots)/v, (A_2M_a+B_2M_a+\cdots)/v, \cdots),$$
$$p_a=\psi(A_1M_a/v, A_2M_a, \cdots),$$
$$p_b=\psi(B_1M_b/v, B_2M_b/v, \cdots),$$

where M_a, M_b, $\cdots$, denote the masses in gram atoms of the constituents a, b, c, $\cdots$, respectively, p, p_a, p_b, $\cdots$, the pressures of the mixture and isolated constituents, respectively, at the volume v and temperature T, and A_1, A_2, $\cdots$ B_1, B_2, $\cdots$, denote functions of T. The exact form of the function ψ cannot yet be stated; its discovery would be extremely important since empirical forms will not suffice for many purposes. The physico-chemical properties of a substance might thus be deduced from those of the constituents. The equations are shown to form the theoretical basis for expressing the purely physical properties of a complex substance, such as its optical, magnetic, and electrical properties, in terms of the similar properties of the constituents. Such determinations should be possible since a complex substance cannot possess any property the possibility of which did not exist in the isolated constituents.

41. Heisenberg's indetermination principle and the motion of free particles. ARTHUR E. RUARK, Mellon Institute of Industrial Research, University of Pittsburgh, and Gulf Production Companies.—Heisenberg (Zeit. f. Phys. . . . . .) has stated that the error, Δq, committed in measuring a coordinate, and the error Δp, in measuring its conjugate momentum, obey the inequality $\Delta q \cdot \Delta p > h$. At first it seems that an idealized apparatus can be devised to measure the position and momentum of a free particle (having unit mass by definition), so accurately that this inequality is violated. Consider two slits a great distance d apart, which are opened for a short time, one after the other, so that the particle passes both slits; it appears that both d, and the time in which the particle traverses d, can be measured with great accuracy, so that the velocity is also accurately known. The flaw in this reasoning is the assumption that *either* q *or* p can be measured with any desired accuracy (at least in thought). The measuring devices are statistical aggregates of atoms and are themselves subject to fluctuations. The conclusion is that Heisenberg's principle is valid.

42. On the polarization of light from hydrogen canal rays. F. G. SLACK, Columbia University.—Light emitted at right angles to a stream of hydrogen canal rays is partially polarized. (Electric vector parallel to the beam). (E. Rupp, Ann. d. Phys. **84**, 94 (1927)). The explanation here offered is based on the theory that an atom excited to a state characterized by a combination of quantum numbers which places the center of gravity of the electronic charge far out from the nucleus favors a transition which results in light polarized with the electric vector parallel to the axis connecting the nucleus with the point of average charge, while an atom excited into the state of the same total quantum number but with a combination of quantum numbers placing the average electronic charge closer to the nucleus (orbits of lesser eccentricity in the Bohr-Sommerfeld theory) favors a transition resulting in light polarized at right angles to this axis. Impacts with the residual gas orient a part of the atoms along the line of the beam in the Bohr-Sommerfeld theory) favor a transition resulting in light polarized at right angles in numbers proportional to their respective effective cross-sectional areas. Thus the resultant light is partially polarized with its electric vector parallel to the beam. The computed ratios of parallel intensity to perpendicular intensity are in agreement with the recent experiments.

43. Reflection of atoms at crystal surfaces. A. ELLETT and H. F. OLSON, University of Iowa.—Cadmium and mercury are almost specularly reflected from a *clean* cleavage surface of rock salt. A beam incident at an angle of 45° to the normal to the crystal surface is reflected at

45°, but has its divergence slightly increased. Sodium is not reflected from a rock salt surface, but merely reevaporates if the temperature of the surface is high enough. Atomic hydrogen striking rock salt escapes without being catalyzed to H_2 if the surface is clean. The distribution of the atoms leaving the surface does not indicate either reevaporation or simple specular reflection. The distribution is quite uniform with some crystals, while with others there are quite definite preferred directions. The nearly specular reflection of mercury and cadmium may be interpreted in terms of the de Broglie and Schroedinger ideas, if we assume a discontinuity in the potential energy at the surface of the crystal, but such an interpretation is obviously not necessary.

44. Changes in the electric field due to lightning discharges. J. C. JENSEN, Nebraska Wesleyan University.—Further investigations confirm the general results previously reported, (Bull. Amer. Meteor. Soc., p. 16, Jan., 1925.) and are in agreement with the conclusions of Wilson and of Schonland and Craib, that the lower pole of thunderclouds usually carries a negative charge. The totals, without respect to the distance of the storm, now give 635 discharges showing a decrease in a negative potential gradient to 322 showing a decrease in a positive gradient. With storms directly overhead, such ratios as 83:11, 83:19, 42:3 and 82:3 have been obtained. Records of individual discharges have been kept, both, as to their distances and the resulting field changes. When a storm is directly overhead discharges from cloud to earth almost invariably indicate a negative charge on the lower pole of the cloud. Photographs of individual flashes in some cases show a branching towards the earth which is in contradiction to the theory of Simpson. The branches are thin and rambling and suggest the electronic darts mentioned by Dorsey as feeding into the main discharge path.

45. On the determination of the piezo-electric constant of a quartz resonator at high frequency. TADASHI FUJIMOTO, Ohio State University.—A quartz resonator was set oscillating by means of a vacuum tube oscillator. A series of characteristic curves for different values of the impressed voltage was taken and the influence of the number of silver coatings on the displacement number per maximum voltage was studied. The influence of air-gap length upon the voltage required to set the quartz resonator into oscillation was studied and from the curves thus obtained the piezo-electric constant of quartz was obtained.

46. The longitudinal thermomagnetic potential difference in a bismuth crystal. C. W. HEAPS, The Rice Institute.—The longitudinal thermomagnetic potential difference has been measured in plates cut from a single large bismuth crystal. Curves give the results in the form of percent change of thermoelectric power plotted as a function of magnetic field strength. Depending upon relative orientations of crystalline axis, magnetic field, and heat current, a positive or a negative effect can be obtained. The maximum effect observed was a 29 percent decrease in a field of 8000 gausses. It is concluded that the direction of the heat current with respect to the crystal axis or with respect to the magnetic field is of importance in modifying the effect; hence this phenomenon cannot properly be considered as simply an effect of the magnetic field on thermoelectric power, though it is sometimes so considered in the literature of the subject.

47. Factors governing the growth of zinc crystals by the Czochralski-Gomperz method, E. P. T. TYNDALL, University of Iowa.—The production of zinc crystals of any desired orientation has been shown by other workers to be conveniently attained by (1) using as a nucleus a small crystal of the desired orientation, or one so inclined as to simulate this, (2) correct adjustment of the temperature of the molten zinc, (3) correct "rate of drawing" of the crystal. The purpose of the present work is to show that the growth of a zinc crystal of any orientation, started as in (1) above, is (1) independent of the "rate of growth," (2) mainly a function of the temperature gradient existing in the column of liquid zinc between the crystal and the surface of the molten metal. By adjustment of the temperature of the molten zinc and by use of a circular nozzle which directs radial blasts of air, or other gas, at the growing crystal, this temperature gradient may be controlled in a fairly quantitative fashion. It is further shown that crystals of either zero or ninety degree orientation grow with a low gradient, and that the necessary gradient increases for both higher and lower orientations, respectively, reaching a maximum at about forty-five degrees.

48. Magnetic reflection. R. B. ABBOTT, Purdue University.—Experiments suggested by Ross (Proc. A.I.E.E., June, 1920) on "Magnetic Reflection" were carried out on a larger scale. A strong magnetic field was produced by a 500-cycle current passing through a large electromagnet. A large plane coil of wire connected to a resistance coupled amplifier with a telephone receiver, was placed along the axis of the magnet and at some distance from it. The coil was oriented in the magnetic field so that no currents were induced in it. A plane thin sheet of zinc about four square feet in area was then placed at some point in the field and rotated around a vertical axis. As the plate was rotated, a 500-cycle note was produced in the telephone and went through a cycle of intensities corresponding to the angles of the zinc plate. The results show that the zinc plate, due to eddy currents, acted very much like a mirror, the angles of incidence and reflection being about equal. These results were obtained when the zinc plate was twenty feet and more from the magnet and detecting coil.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

49. Time lag differences of the Faraday effect in several mixtures and chemical compounds. FRED ALLISON, Alabama Polytechnic Institute.—It has been found that the Faraday effect lags behind the magnetic field longer in one liquid than in another (Beams and Allison, Phys. Rev. **29**, 161 (1927)) and that this lag increases with decreasing wave-length of light (Allison, Phys. Rev. **30**, 66 (1927)). A study of these lags is now in progress with mixtures of these same liquids and also with certain chemical compounds. When two of the liquids are mixed, each liquid retains its own lag, uninfluenced by the presence of the other liquid. The same results were observed for mixtures of several liquids. The compounds thus far studied are acetic acid, several primary alcohols and their acetic acid esters. Lags for various wave-lengths were measured in ethyl alcohol, acetic acid and ethyl acetate. The acetate shows two time lag differences for each wave-length, which are those of the alcohol and the acid. The same results are found for acetic acid, amyl, *n*-butyl and methyl alcohols and the corresponding esters. The lags of the alcohol and the acid are not affected by the chemical union. The ester shows no lag of its own. The method may possibly find an application in detecting the presence of certain constituents of some liquids.

50. A design of x-ray tube for use with vacuum spectrograph or crystal diffraction apparatus. ELMER DERSHEM, University of California.—This tube is almost entirely of metal. The target, filament holder and cathode focusing tube have metal to metal ground cone seals, permitting instant removal for cleaning or for replacement of a burned out filament. Since the target and the cathode focusing tube are very close together (about 3 mm) the limitation of thermionic current by space charge effect is very considerably removed. A saturation current of 140 milliamperes being reached with an alternating e.m.f. of 700 volts and one of 200 milliamperes at 1000 volts. The tube will operate satisfactorily at an impressed e.m.f. of 20 kv even though the air pressure within is above 0.01 mm of mercury.

51. The additive nature of the internal energy and entropy of a substance under certain conditions. R. D. KLEEMAN, Schenectady, New York.—At the previous meeting of the A.A.A.S. the author read a paper in which it was shown that the controllable internal energy and entrophy are both zero for a substance or mixture in the condensed state under its vapor pressure at the absolute zero of temperature. The subject has since been further developed to a considerable extent (J. Phys. Chem., **31**, 747 (1927); **31**, 937 (1927); **31**, 1559 (1927). Phil. Mag., **3**, 883 (1927); **4**, 257 (1927); Science, **65**, 210 (1927); **65**, 426 (1927); **66**, 218 (1927). In the present paper it is shown (from the nature of these quantities without introducing any assumptions) that the internal energies of a number of gaseous non-dissociated compounds of the same type at the same temperature are additive quantities of the atoms, and that this holds also for the differences between the entrophy of an arbitrarily selected compound and the entropies of the remaining compounds. These additive laws, for which evidence already exists, will tremendously reduce the labor of determining the foregoing quantities, and the

important quantities from the chemists' point of view, the free energies. Furthermore, by considering more data than is necessary an important check on the accuracy of the calculations would be obtained.

52. Infrared absorption by the N-H bond. JOSEPH W. ELLIS, University of California.—The infrared absorption spectra of several primary, secondary and tertiary aryl, alkyl and aryl alkyl amines have been examined below 3μ with a recording spectrograph. Bands, varying in wave-length between $1.04–1.07\mu$ and $1.49–1.55\mu$, are found to be present in all of the primary amines and with less intensity in all of the secondary amines. Since they disappear in the spectra of the tertiary amines they are assumed to originate in oscillations of the nitrogen-hydrogen atom pair. The wave-lengths are greatest for the alkyl amines and least for the aryl amines, thus suggesting that the effect of unsaturation in an aryl group is extended to an attached amino group. These two bands, taken with one exhibiting a similar behavior found by Bell (J.A.C.S. **46,** 2192, 3039; **48,** 813, 818; **49,** 1837) at $2.80–3.05\mu$ form an anharmonic series when expressed in frequencies. A band at 0.79μ observed with a 15 cm cell of aniline and one observed visually at 0.650μ by Russell and Lapraik (Jl. Chem. Soc. **39,** 168 (1881)) in a still longer cell are interpreted as the fourth and fifth members of such a series. Thus there is a similarity in the behavior toward infrared frequencies between the N–H and the C–H bonds. (See abstract No. 36).

53. On the collision process accompanying the combination of nitrogen atoms in active nitrogen. BERNARD LEWIS, National Research Fellow, University of Minnesota.—Bonhoeffer and Kaminsky have pointed out that the assumption of a triple collision between two N atoms and a N_2 molecule in active nitrogen resulting in an active unstable molecule, leads to conclusions at variance with certain experimental facts. Another triple collision possibility (forming a metastable excited molecule) is considered and it is shown that unless the relative efficiencies of two competing collision processes change with pressure, (considered unlikely) furnishing a possible solution, these results are also contrary to fact. The necessity for a triple collision in the combination of N atoms is therefore discarded. A two body collision between N atoms is next considered, which leads to results in agreement with B. and K.'s observations and also explains other active nitrogen phenomena. Unlike the case of hydrogen combination, where the intervention of a third body is necessary, the N_2 molecule may be formed in a two body process since it possesses quantum states, corresponding to the energy of combination plus the relative kinetic energy of the atoms, from which it can radiate. It is suggested that the N_2 molecule in this electron level (9.3 volts) may possess an electric moment which enhances the possibility of a two body collision.